

We Claim:

1. A radiation curing apparatus, comprising:

a plurality of solid state radiation sources to generate radiation that cures a first material;

5 a plurality of optical concentrators, wherein each concentrator receives radiation from a corresponding one of said solid state radiation sources;

a plurality of optical waveguides, wherein each of the plurality of optical waveguides includes a first end and a second end, wherein each first end receives concentrated radiation from a corresponding concentrator; and

10 a support structure to stabilize the plurality of optical waveguides between the first and second ends.

2. The radiation curing apparatus according to claim 1, wherein the plurality of solid state radiation sources comprises a plurality of LED dies.

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3. The radiation curing apparatus according to claim 2, further comprising:

an interconnect circuit layer to provide electrical connection to the plurality of LED dies;

a heat exchange unit; and

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a thermally conductive adhesive to thermally couple the interconnect circuit layer to the heat exchange unit.

4. The radiation curing apparatus device according to claim 1, wherein the plurality of waveguides comprises a plurality of optical fibers.

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5. The radiation curing apparatus according to claim 4, further comprising a fiber array connector to support the first ends of the plurality of fibers in a defined pattern.

6. The radiation curing apparatus according to claim 5, wherein the support structure comprises a housing that encloses at least a portion of the plurality of optical fibers.

7. The radiation curing apparatus according to claim 1, further comprising a heat exchange unit disposed opposite to a direction of the emitted radiation.

8. The radiation curing apparatus according to claim 5, further comprising a banding to surround and secure at least the first portion of the second ends of the fibers.

9. The radiation curing apparatus according to claim 9, wherein the banding is reconfigurable.

10. The radiation curing apparatus according to claim 1, further comprising:  
first and second alignment pins disposed longitudinally along a length of the radiation curing apparatus, wherein the interconnect circuit layer includes alignment holes to receive the alignment pins.

11. The radiation curing apparatus according to claim 1, further comprising:  
an optical element to collect and distribute optical radiation from the optical waveguide second ends in a selected light distribution pattern.

12. The radiation curing apparatus according to claim 1, wherein solid state radiation sources emit a high intensity irradiance profile that cures the first material in cross-machine and machine directions.

13. The radiation curing apparatus according to claim 4, wherein the second ends of the fibers are bundled to provide a uniform output beam across the fiber array.

14. The radiation curing apparatus according to claim 2, further comprising:

an interconnect circuit layer to provide electrical connection to the plurality of LED dies, wherein the plurality of LED dies is arranged in a first grouping and a second grouping, wherein the first grouping of LED dies is connected to a first portion of the interconnect circuit layer and the second grouping of LED dies is connected to a second portion of the interconnect circuit layer.

15. The radiation curing apparatus according to claim 14, wherein a first output intensity of at least one LED die of the first grouping of LED dies is controllable separate from a second output intensity of at least one LED die of the second grouping of LED dies.

16. The radiation curing apparatus according to claim 15, wherein the first material receives uniform radiation when one of said groupings of LED dies is not activated.

17. The radiation curing apparatus according to claim 2, wherein at least a portion of the plurality of LED dies comprise ultraviolet emitting LED dies.

18. The radiation curing apparatus according to claim 4, wherein the first material is disposed on a non-uniform structure and wherein the second ends of the fibers are patterned to uniformly irradiate the first material.

19. A radiation curing system, comprising:

a solid state radiation source, comprising

a plurality of LED dies to generate radiation that cures a radiation curable chemical formulation;

a plurality of optical concentrators, wherein each concentrator receives radiation from a corresponding one of said LED dies;

a plurality of optical fibers, wherein each of the plurality of optical fibers includes a first end and a second end, wherein each first end receives concentrated radiation from a corresponding concentrator; and

a substrate to support the radiation-curable chemical formulation.

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20. The radiation curing system according to claim 18, further comprising a controller, coupled to the solid state light source, to selectively activate one or more groups of the plurality of LED dies.

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21. The radiation curing system according to claim 20, wherein the controller is adapted to selectively activate a first group of LED dies to emit radiation corresponding to a first absorption band of a first radiation-curable chemical formulation.

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22. The radiation curing system according to claim 21, wherein the controller is adapted to selectively activate a second group of LED dies to emit radiation corresponding to a second absorption band of a second radiation-curable formulation.

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23. The radiation curing system according to claim 19, further comprising a heat exchange unit coupled to the solid state light source that is disposed opposite a direction of output radiation.

24. The radiation curing system according to claim 20, wherein the controller selectively activates a first LED die grouping in response to a trigger signal.

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25. The radiation curing system according to claim 20, wherein the controller sends an increased drive current to a first LED die channel to compensate for a reduced emission output from a second LED die channel.

26. The radiation curing system according to claim 19, wherein the plurality of fibers output a selected steerable illumination pattern.

27. The radiation curing system according to claim 19, wherein the substrate is disposed on a movable platform.

28. The radiation curing system according to claim 19, wherein the substrate is suspended between movable rollers.

29. The radiation curing system according to claim 19, further comprising a collecting lens interposed at a selected distance between the second ends of the fibers and the radiation-curable substrate.

30. The radiation curing system according to claim 20, wherein the radiation-curable chemical formulation is disposed on a non-uniform structure and wherein the second ends of the fibers are patterned to uniformly irradiate the radiation-curable chemical formulation.

31. A method of curing a radiation curable chemical formulation, comprising:  
providing a solid state radiation source that includes a plurality of LED dies to generate curing radiation, a plurality of optical concentrators, wherein each concentrator receives curing radiation from a corresponding one of said LED dies, and a plurality of optical fibers, wherein each of the plurality of optical fibers includes a first end and a second end, wherein each first end receives concentrated curing radiation from a corresponding concentrator; and

exposing the radiation-curable chemical formulation to the curing radiation, wherein a substrate supports the radiation-curable chemical formulation.

32. The method according to claim 31, wherein providing a solid state radiation source further comprises providing a first group of LED dies to emit curing radiation corresponding to a first absorption band of a first radiation-curable chemical formulation.

5 33. The method according to claim 32, wherein providing a solid state radiation source further comprises providing a second group of LED dies to emit curing radiation corresponding to a second absorption band of a second radiation-curable chemical formulation.

10 34. The method according to claim 32, further comprising selectively controlling a curing radiation output of the solid state radiation source.

35. The method according to claim 34, further comprising selectively activating one or more groups of the plurality of LED dies.

15 36. The method according to claim 34, further comprising providing a steerable illumination pattern.

20 37. The method according to claim 31, wherein the exposing the radiation-curable chemical formulation to the curing radiation comprises emitting a substantially uniform, high intensity irradiance profile that cures the radiation-curable chemical formulation in cross-machine and machine directions.